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ABUNDANCE AND LENGTH COMPOSITION OF SOCKEYE SALMON AND LEAST CISCO IN PELAGIC WATERS OF HARDING LAKE, ALASKA, 1988[1]

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

A tow net was used to sample the pelagic zone of Harding Lake, Alaska, during October 1988. One-hundred and forty-seven sockeye salmon *Oncorhynchus nerka* and 219 least cisco *Coregonus sardinella* were captured in 34 surface and 9 sub-surface tows. Using area-swept methodology, 25,495 sockeye salmon and 33,301 least cisco were estimated to have been in the upper 9.14 meters of water of Harding Lake. Average fork length of captured sockeye salmon was 72 millimeters and average fork length of captured least cisco was 155 millimeters. Density of stocked sockeye salmon was in the low range of densities reported for natural stocks of sockeye salmon in Alaskan lakes, but growth rate was slightly higher than that reported for natural stocks. Survival rate of stocked sockeye salmon in Harding Lake was estimated to be five percent over the course of their first four months in the lake.

KEY WORDS: Sockeye salmon, least cisco, *Oncorhynchus nerka*, *Coregonus sardinella*, tow netting, abundance, bootstrapping, survival rates, catch rates, length frequency, age composition, stomach contents, Harding Lake.

INTRODUCTION

Sockeye salmon *Oncorhynchus nerka* were first introduced into Harding Lake in May and June of 1988 when 500,000 sac-fry from the Gulkana River Incubation Facility were stocked. The Department's intent in stocking sockeye salmon into Harding Lake was to introduce a game fish that will: (1) occupy the pelagic zone; and, (2) provide competition to the native stock of stunted least cisco *Coregonus sardinella* which are unused by recreational fishermen. It is anticipated that these sockeye salmon, stocked into a land-locked lake, will eventually provide the first recreational fishery for kokanee in interior Alaska.

The major management questions were as follows: Did the stocked fish survive? If so, how many? Are the growth and survival rates adequate such that a target sport fishery could develop? Should the lake be stocked again in 1989? And, if so, at what stocking rate? The specific objectives were to estimate abundance and mean length of sockeye salmon in Harding Lake. Because the sockeye salmon were expected to occupy pelagic waters during the fall of the year (Foerster 1968), tow nets were chosen as the sampling tool. Also, because least cisco were the primary species utilizing pelagic waters prior to the introduction of sockeye salmon, that abundance and size composition of the least cisco population occupying the pelagic zone were estimated concurrently with the target sockeye salmon population.

Description of Harding Lake

Harding Lake is located 70 km south and east of Fairbanks, Alaska, near the Richardson Highway at milepost 322 (Figure 1). The lake is bowl shaped; landlocked; and is fed by springs, hillside runoff, and two small inlets. Surface elevation of Harding Lake is 218 m, maximum depth is 44 m, area is 1,000 ha, and volume is 138 million m^3. It is a clear water lake with secchi depths typically ranging from 5 to 10 m. Thirty-six percent of the lake bottom lies within the littoral zone.

Harding Lake is by far the largest road-side lake in the Fairbanks vicinity which is the second largest population center in Alaska. Private recreational cabins and homes surround three quarters of the perimeter of Harding Lake. Additionally, a State of Alaska campground and boat launch are located along the western shore of the lake. The lake is used extensively for water sports such as swimming and water skiing. Harding Lake, because of its size, access, and proximity to Fairbanks, has the potential to provide a major sport fishery for interior Alaska anglers.

Harding Lake Sport Fishery and Historical Stocking Program

Recreational fishing does occur in Harding Lake. In 1987, 3,371 anglers during 4,032 trips in 5,125 days harvested 118 rainbow trout *Oncorhynchus mykiss*, 79 Arctic grayling *Thymallus arcticus*, 1,886 northern pike *Esox lucius*, and 53 burbot *Lota lota* from Harding Lake (Mills 1988). In most years, anglers also harvest a few lake trout *Salvelinus namaycush*.

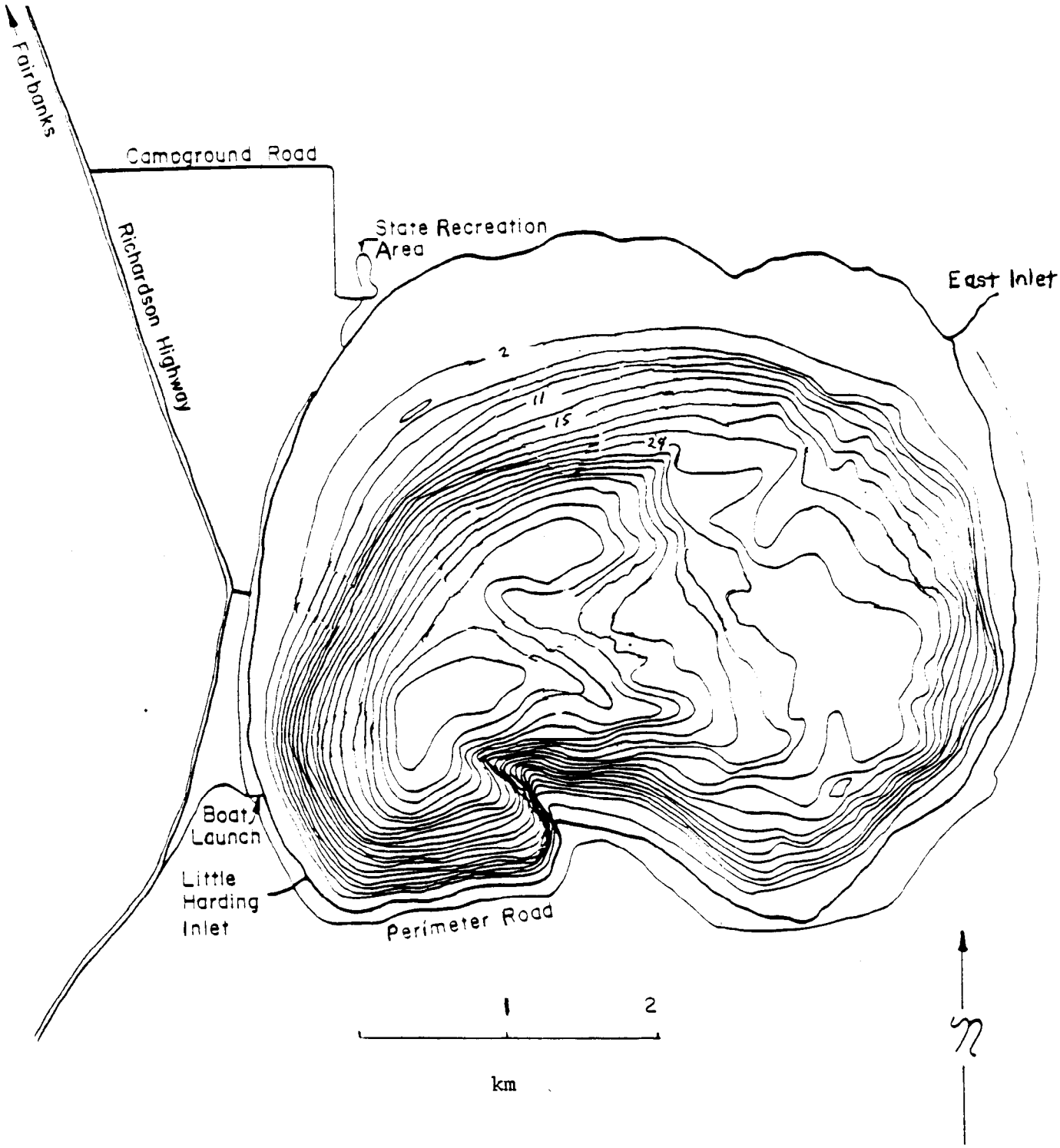

Figure 1. Contour map of Harding Lake.

Although recreational fishing takes place in Harding Lake, there is reason to believe that the lake is not providing an optimal or maximum level of recreational fishing at the present time. Quartz Lake (about 600 ha), located an additional 70 km down the Richardson Highway provided over 20,400 angler days of recreational fishing in 1987 (Mills 1988). Hence, in 1988, Quartz Lake provided approximately seven-fold the number of fishing days on a per area basis (Quartz Lake: 34 angler-days per hectare and Harding Lake: 5 angler-days per hectare) that Harding Lake provided even though Quartz Lake is located about twice as far from Fairbanks and has far fewer recreational cabins and other recreational developments. Clearly, the sport fishing potential of Harding Lake has not been fully realized by area anglers.

Species native to Harding Lake include northern pike, burbot, least cisco and slimy sculpin *Cottus cognatus*. Because native fish stocks are limited and because Harding Lake has the potential to support a major recreational fishery, various introductions of non-native fish into the lake by the Alaska Department of Fish and Game (ADF&G) have taken place over the past 20 years. Species stocked into Harding Lake by ADF&G include lake trout, coho salmon *Oncorhynchus kisutch*, sheefish *Stenodus leucichthys*, rainbow trout, Arctic grayling, Arctic char *Salvelinus malma*, and sockeye salmon.

The success of various introductions of game fish into Harding Lake through the ADF&G stocking program has been mixed. The first species introduced into Harding Lake was lake trout. Adult lake trout were transplanted during the 1960's. Lake trout exhibited rapid growth and some of the fish naturally reproduced. Since that time, a small lake trout fishery has developed. The second species introduced into Harding Lake was coho salmon. Only a few coho salmon were ever harvested by anglers even though the fish that survived grew particularly well. During the mid 1980's, sheefish were stocked into Harding Lake. However, the sheefish stocking program was a failure. Only a few sheefish were ever harvested even though many thousands of fingerlings of various sizes were stocked. Stocking of rainbow trout and Arctic grayling was initiated in 1986 and based upon reported harvests (see Mills 1988), these two introductions are judged at least partially successful. In total however, the introduction of these five species over the past 20 years has failed to meet ADF&G's fishery management objective; to stock game fish and provide the basis for a major (10 to 20 angler days per hectare per year) recreational fishery in Harding Lake.

Arctic char were first stocked into Harding Lake in 1988. It is hoped that the stocked Arctic char will provide the nucleus of a major fishery over the next few years, and the evaluation of the introduction of Arctic char will be taken up in a future report.

METHODS

A tow net was used to catch pelagic fish in Harding Lake between 7:45 PM and 5:20 AM from 3 October through 7 October, 1988. Surface tow netting was conducted during three nights resulting in 34 individual tows. Nine sub-surface tows were conducted on 6 October.

Description of Gear

The tow net used in this study was 2.75 m wide by 2.75 m deep by 8.23 m long. The net had nylon taped seams and was dyed green. The forward section (2.44 m long) tapered from 2.75 m to 1.83 m and was made of #40, 37 mm mesh, knotless nylon. The mid-section (2.75 m long) tapered from 1.83 m to a 0.92 m hoop of 9.5 mm stainless steel. The mid-section was made of #16, 13 mm mesh, knotless nylon. The rear section of #16, 6 mm mesh knotless nylon was 3.04 m long and contained a 3 mm mesh liner in the last 0.61 m of length. The cod end of the tow net had a 500 mm zipper for removal of fish. Two pieces of 13 mm diameter conduit (3 m long each) were attached to the corners of the net to provide vertical rigidity. Large plastic floats (0.6 m in diameter) were attached to the two top corners of the net (attached directly to corners for surface tows and attached with 9 m nylon ropes for sub-surface tows). Weights were attached to the lower entrance of the tow net (4.5 kg for surface tows and 30 kg for sub-surface tows). The net was rigged with two 9.14 m bridles of nylon rope attached to the corners on each side of the net.

Method of Fishing

Two boats pulled the tow net through the water. The net was attached to each boat with a 40 m nylon rope. The two boats were attached to each other with a 20 m nylon rope tied to the bow of each boat. After the net was placed in the water, the two boats slowly pulled away from the net and from each other as the attachment ropes were payed out. Once the attachment ropes were fully payed out and tight, the two boats came up to speed (1.15 m per second for surface tows and 0.38 m for sub-surface tows). Thereafter, each boat maintained its speed with the aid of a tachometer. Tows were timed and most were 20 minutes in duration. Surface tows sampled the top 2.75 meters of water in Harding Lake along a line about one half of the distance across the lake. A third boat equipped with sonar was used to determine the water zone actually being sampled by sub-surface tows (6.40 to 9.14 m deep zone). A tow was concluded when the outboard engines were turned off and the tow net was pulled by hand into one of the boats. The nets catch was removed and placed into a labelled plastic jar. At that time, the net was either reset immediately or the boats were moved a short distance and the net was reset for the next tow. Tow direction was largely a function of the boat drivers intuition concerning which direction a tow could be conducted for a full 20 minutes without hitting the bottom or a shore while at the same time attempting to fish throughout the lake during the night.

Fish Sampling

The day following tow netting, sampling jars were emptied, catches were sorted by species, catch by species was counted, and fork lengths (FL) of all fish were measured to the nearest mm. The cumulative catch by species on the night of 6 October was weighed to the nearest 0.1 grams. Scales were taken from 60 least cisco for age determination. Scales were cleaned and placed on gummed cards. Scale impressions on 20 mil acetate were made using a Carver press at 60,000 kg /cm^2 heated to 93° C for 30 seconds. Annuli were counted along the dorsal radius with the aid of a 3M Consultant Microfiche reader. The stomach contents of 50 sockeye salmon were emptied into a labeled jar containing 95 %

ethyl alcohol. Later, samples of the solution were examined under a dissecting microscope and the percent volume of various food types was subjectively estimated. Stomach contents of 50 least cisco were similarly emptied into a labeled jar and later examined under a dissecting microscope.

Data Analysis

Mean catch and variance of mean catch was estimated with bootstrap techniques (Efron 1982). A computer program was developed that randomly selected tows (with replacement) from the original data until a bootstrap sample with a desired sample size was obtained (34 tows for surface sets and 9 tows for sub-surface sets). Then the program calculated the mean catches of sockeye salmon and of least cisco for the bootstrap sample. This process was repeated 1,000 times producing 1,000 bootstrap means for each combination of species and depth. The mean of all 1,000 bootstrapped surface sample means was used as the measure of mean abundance per tow for surface waters (0.00 to 2.75 m). The mean of all 1,000 bootstrapped sub-surface sample means was used as the measure of mean abundance per tow for sub-surface waters (6.40 to 9.14 m). Likewise the variances of the various 1,000 bootstrapped sample means was used to estimate the variances and standard errors of the estimates of mean catch of sockeye salmon and least cisco in surface and sub-surface waters. These data were combined to provide an estimate (and variance) of sockeye salmon and least cisco abundance in the upper 9.14 m of Harding Lake as follows:

(1) $\hat{T} = (\bar{U})\phi_u + (\bar{M})\phi_m + (\bar{L})(3.01)\phi_l$ = Estimated Abundance of Sockeye Salmon or Least Cisco in the Upper, Middle, and Lower Zones of Harding Lake; and,

(2) $V[\hat{T}] = \theta_u^2 V[\bar{U}] + \theta_l^2 V[\bar{L}]$ = Variance of Estimated Abundance of Sockeye Salmon or Least Cisco in the Upper, Middle, and Lower Zones of Harding Lake;

where:

$\bar{U}$ = Mean Catch per 20 Minute Standard Tow in Upper Zone (0.00 - 2.75 m);

$\bar{L}$ = Mean Catch per 20 Minute "Slow" Tow in Lower Zone (6.40 - 9.14 m);

$\bar{M} = \bar{U}(0.5) + \bar{L}(3.01)(0.5)$ = Estimated Mean Catch in 20 Minute Standard Tow in Middle Zone (2.76 - 6.39 m); note, the 3.01 constant adjusts for the fact that surface tows were conducted 3.01 times as fast as "slow" tows in sub-surface waters;

$$\phi_u = \frac{\text{Volume of Upper Zone}}{\text{Volume per Tow in Upper Zone}};$$

$$\phi_l = \frac{\text{Volume in Lower Zone}}{\text{Volume per Tow in Upper Zone}};$$

$$\phi_m = \frac{\text{Volume of Middle Zone}}{\text{Volume per Tow in Upper Zone}};$$

$$\theta_u = \phi_u + \phi_m/2; \text{ and,}$$

$$\theta_l = \phi_l + (3.01)\phi_m/2.$$

Mean length (and variance) for sockeye salmon and least cisco populations sampled from Harding Lake was calculated with standard normal procedures. Average weights of fish caught by species were determined by dividing the total weight of the catch of species "x" during the night of 6 October by the number of species "x" caught that night.

RESULTS AND DISCUSSION

One-hundred and forty-seven sockeye salmon were caught in 43 tows made in Harding Lake during October 1988 (Table 1). Catches of sockeye salmon ranged from 0 to 46 fish with the most frequent catch being zero sockeye salmon (21 of 43 cases). Mean catch of sockeye salmon during 20-minute tows in surface waters was 4.56 fish (Table 2) and distribution of these bootstrap means was skewed slightly to the left (Figure 2). Mean catch of sockeye salmon in sub-surface waters was 0.98 fish (Table 2) and distribution of sub-surface bootstrap means was normal (Figure 2). Average catches of sockeye salmon during 20-minute tows in a series of eight lakes located in the Bristol Bay and Cook Inlet areas of Alaska ranged from 0.88 to 269 fish (Table 3). Based upon data reported in Table 3, density of age zero sockeye salmon during fall 1988 in Harding Lake was in the lower range of reported densities of native sockeye salmon stocks of Alaska.

Abundance of sockeye salmon in the upper 9.14 m of Harding Lake during October 1988 was estimated to be 25,495 fish (SE = 7,231 fish). Abundance in surface waters (0 to 2.74 m) was estimated to be 10,798 fish, with abundance declining to 9,514 and 5,183 fish in the 2.75 to 6.39 m and the 6.40 to 9.14 m zones respectively (Table 2). Based on the trend of declining abundance with depth

Table 1. Catches of fish from tow net sampling of Harding Lake, 1988.

Night of	Depth	Start Time	End Time	Tow Duration (Minutes)	Catch of Sockeye Salmon	Catch of Least Cisco	Catch of AC[1]
10/3-4/88	Surface	10:05	10:23	18	3	1	0
10/3-4/88	Surface	11:33	11:53	20	5	6	0
10/3-4/88	Surface	12:06	12:26	20	8	1	0
10/3-4/88	Surface	12:37	12:57	20	0	1	0
10/3-4/88	Surface	1:13	1:33	20	0	2	0
10/3-4/88	Surface	1:45	2:05	20	0	4	0
10/3-4/88	Surface	2:26	2:46	20	0	9	0
10/3-4/88	Surface	3:02	3:18	16	0	4	0
10/3-4/88	Surface	3:36	3:56	20	0	13	0
10/3-4/88	Surface	4:09	4:29	20	3	7	0
10/3-4/88	Surface	4:40	5:00	20	0	1	0
10/4-5/88	Surface	7:45	8:05	20	20	2	0
10/4-5/88	Surface	8:11	8:31	20	46	4	0
10/4-5/88	Surface	8:42	9:02	20	29	6	0
10/4-5/88	Surface	9:14	9:34	20	3	5	0
10/4-5/88	Surface	11:26	11:46	20	1	3	0
10/4-5/88	Surface	11:58	12:08	10	1	1	0
10/4-5/88	Surface	1:41	2:01	20	1	0	0
10/4-5/88	Surface	2:09	2:29	20	0	6	0
10/4-5/88	Surface	2:38	2:58	20	0	4	0
10/4-5/88	Surface	3:08	3:28	20	1	2	0
10/4-5/88	Surface	3:36	3:56	20	0	2	0
10/4-5/88	Surface	4:04	4:22	18	0	2	0
10/4-5/88	Surface	4:31	4:51	20	0	1	0
10/4-5/88	Surface	5:00	5:20	20	0	1	0
10/5-6/88	Sub-surf	8:21	8:41	20	0	0	0
10/5-6/88	Sub-surf	8:50	9:10	20	0	0	0
10/5-6/88	Sub-surf	9:18	9:38	20	0	1	0
10/5-6/88	Sub-surf	11:45	12:05	20	2	6	0
10/5-6/88	Sub-surf	12:14	12:34	20	1	1	0
10/5-6/88	Sub-surf	12:43	1:03	20	3	1	0
10/5-6/88	Sub-surf	1:13	1:33	20	3	1	0
10/5-6/88	Sub-surf	1:42	2:02	20	0	0	0
10/5-6/88	Sub-surf	2:08	2:28	20	0	0	0
10/6-7/88	Surface	7:42	8:02	20	0	2	0
10/6-7/88	Surface	8:13	8:33	20	0	17	0
10/6-7/88	Surface	8:40	9:00	20	0	16	1
10/6-7/88	Surface	9:06	9:26	20	1	13	0
10/6-7/88	Surface	9:33	9:53	20	8	20	0
10/6-7/88	Surface	10:03	10:23	20	2	22	0
10/6-7/88	Surface	10:29	10:49	20	3	4	0
10/6-7/88	Surface	10:59	11:16	17	1	12	0
10/6-7/88	Surface	11:23	11:43	20	2	15	1
Totals				839	147	219	2

[1] AC = Arctic char

Table 2. Abundance estimates and associated statistics from sockeye salmon and least cisco, Harding Lake tow netting, 1988.

Statistic	Depth Zone of Harding Lake (meters of depth): Upper (0.00-2.74)	Middle (2.75-6.39)	Lower (6.40-9.14)	Total (0.00-9.14)
Bootstrap Estimates; Sockeye Salmon:				
Mean	4.5617		0.9840	
Variance	3.5521		0.1762	
Standard Error	1.8847		0.4198	
Bootstrap Estimates; Least Cisco:				
Mean	6.4255		1.0985	
Variance	1.3737		0.3527	
Standard Error	1.1720		0.5936	
Est. Volume of Water (x 10^6):	24.305	25.969	17.968	68.242
Expansion Factors (ϕ in EQ. 1):	2,367	2,529	1,750	
Abundance Estimates; Sockeye Salmon:				
Mean	10,798	9,514	5,183	25,495
Variance				52,284,422
Standard Error				7,231
Coefficient of Variation				28.4%
Abundance Estimates; Least Cisco:				
Mean	15,209	12,306	5,786	33,301
Variance				29,003,613
Standard Error				5,386
Coefficient of Variation				16.2%

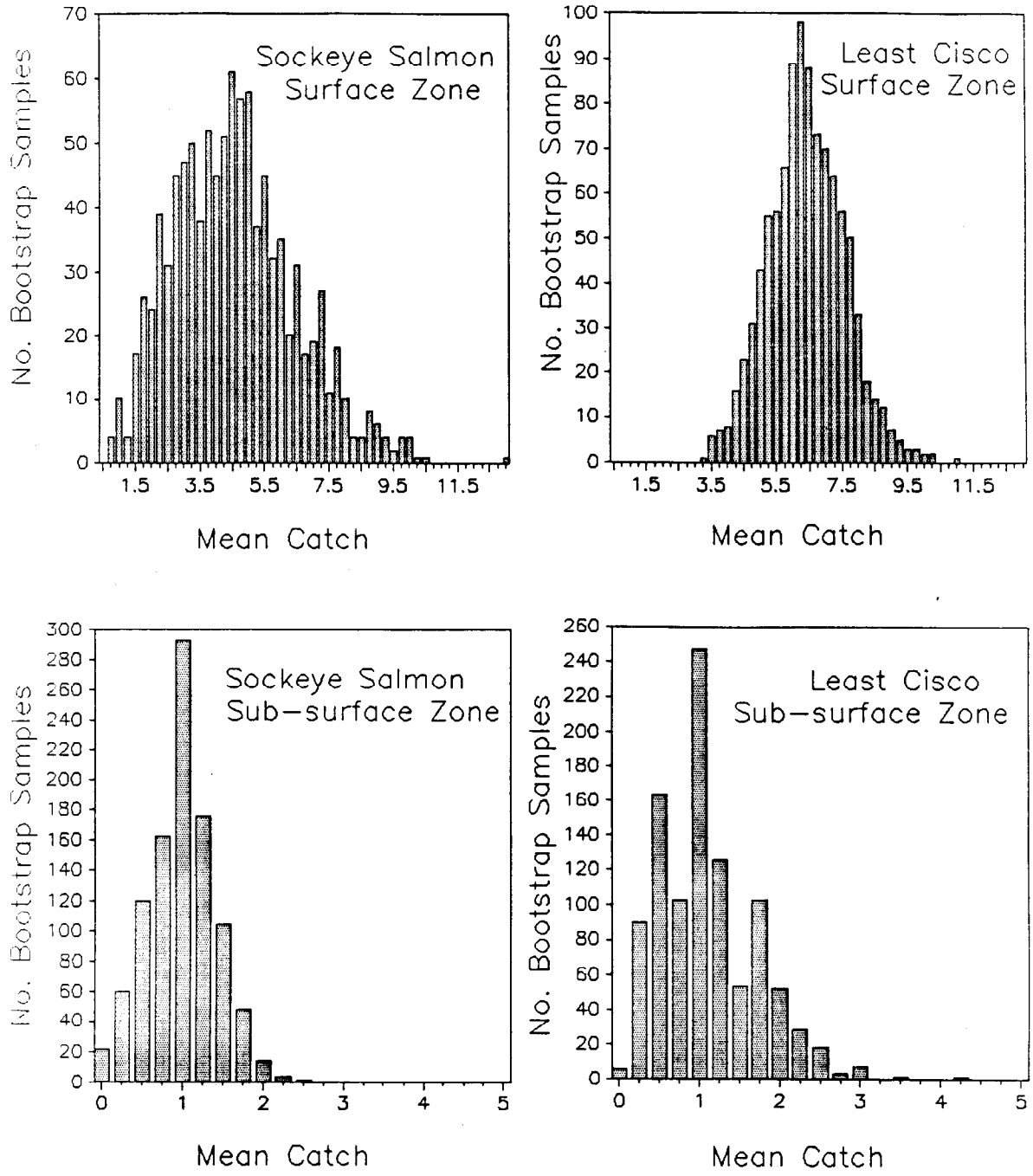

Figure 2. Frequency of bootstrap estimates of mean catches of sockeye salmon and least cisco in surface and in sub-surface zones of Harding Lake, 1988.

Table 3. Reported catches of age zero sockeye salmon in tow nets fished for 20 minutes in various Alaskan lakes.

Source	Location	Year	Catch of Age Zero Sockeye Salmon	Comments
Clark (1980)	Becharof Lake	1974	Ave. = 33.6	Speed: 1.10 m per sec.
Clark (1980)	Becharof Lake	1975	Ave. = 269.0 Range (various areas) = 0.4 to 2,188	Speed: 1.10 m per sec.
Clark (1980)	Upper Ugashik Lk.	1974	Ave. = 19.4	Speed: 1.10 m per sec.
Clark (1980)	Lower Ugashik Lk.	1974	Ave. = 4.2	Speed: 1.10 m per sec.
Rogers & Newcome (1975)	Ualik Lake	1974	Ave. = 0.88	5 min. tows @ 3,493 m^3 expanded by 2.94 fold
Rogers & Newcome (1975)	Amanka Lake	1974	Ave. = 47.9	5 min. tows @ 3,493 m^3 expanded by 2.94 fold
Waltemyer (1981)	Kenai Lake	1974 - 1979	Range: 6.2 - 204.0	Speed: 1.20 m per sec.
Waltemyer (1981)	Skilak Lake	1974 - 1979	Range: 14.2 - 96.8	Speed: 1.20 m per sec.
Waltemyer (1981)	Tustemena Lake	1974 - 1979	Range: 22.4 - 56.4	Speed: 1.20 m per sec.

(Figure 3), it may be that the estimate of 25,495 sockeye salmon is a minimum estimate.

Survival rate of sockeye salmon stocked into Harding Lake during May and June of 1988 through October of the same year (the first four months of residence) was just over 5% (25,495 fish survived; 500,000 fish stocked). In general, the survival rate of sockeye salmon is about 8% from the time the population migrates into a lake after emergence to the time of their seaward migration as smolts, typically 1 to 3 years later (Foerster 1968). Therefore, it appears that survival of sockeye salmon stocked into Harding Lake is lower than what could be expected in typical lakes that support sockeye salmon.

Fork lengths of the 147 sockeye salmon caught during tow netting of Harding Lake in October 1988 averaged 72 mm (SE = 0.34 mm) and weight averaged 3.47 gr (Table 4). Fork lengths of these sockeye salmon ranged from 62 to 83 mm and distribution of lengths appeared normal (Figure 4). Reported average fork lengths of age zero sockeye salmon sampled from late August to early October for populations in a series of eight lakes located in the Bristol Bay and Cook Inlet areas of Alaska ranged from 35.0 to 69.6 mm (Table 5). Based upon data reported in Table 5, growth of age zero sockeye salmon in Harding Lake was slightly faster than that reported for several native stocks of Alaskan sockeye salmon.

Two-hundred and nineteen least cisco were caught in 43 tows made in Harding Lake (Table 1). Catches of least cisco ranged from 0 to 22 fish with the most frequent catch being one least cisco (11 of 43 cases). Mean catch of least cisco during 20-minute tows in surface waters was 6.43 fish (Table 2) and distribution of bootstrap means was normal (Figure 2). Mean catch of least cisco in sub-surface waters was 1.10 fish (Table 2); distribution of bootstrap means was skewed slightly to the left (Figure 2).

Abundance of least cisco in the upper 9.14 m of Harding Lake during October 1988 was estimated to be 33,301 fish (SE = 5,386 fish). Abundance of least cisco in surface waters (0 to 2.74 m) was estimated to be 15,209 fish, with abundance declining to 12,306 and 5,786 fish in the 2.75 to 6.39 m and the 6.40 to 9.14 m zones, respectively (Table 2).

Fork lengths of the 219 least cisco caught during tow netting of Harding Lake in October 1988 averaged 155 mm (SE = 0.92 mm). Weight of the sampled least cisco averaged 31.55 gr (Table 4). Fork lengths of least cisco ranged from 106 to 192 mm (Table 4) and a non-normal distribution was apparent (Figure 4). The non-normal length distribution was a result of multiple age classes of least cisco were represented in the sample. Age of sampled least cisco ranged from 0 to 3 (Table 4). Age 0 least cisco averaged 111 mm FL, age 1 least cisco averaged 146 mm FL, age 2 least cisco averaged 161 mm FL, and age 3 least cisco averaged 192 mm FL (Table 4). Overlap of various length classes across more than one age class was apparent (Figure 5).

The least cisco population in the Chatanika River is one of the few least cisco populations from interior Alaska that has been studied. Least cisco in the Chatanika River first spawn at age 2 at an average length of 288 mm FL (Hallberg and Holmes 1987). Fish up to age 7 at an average length of

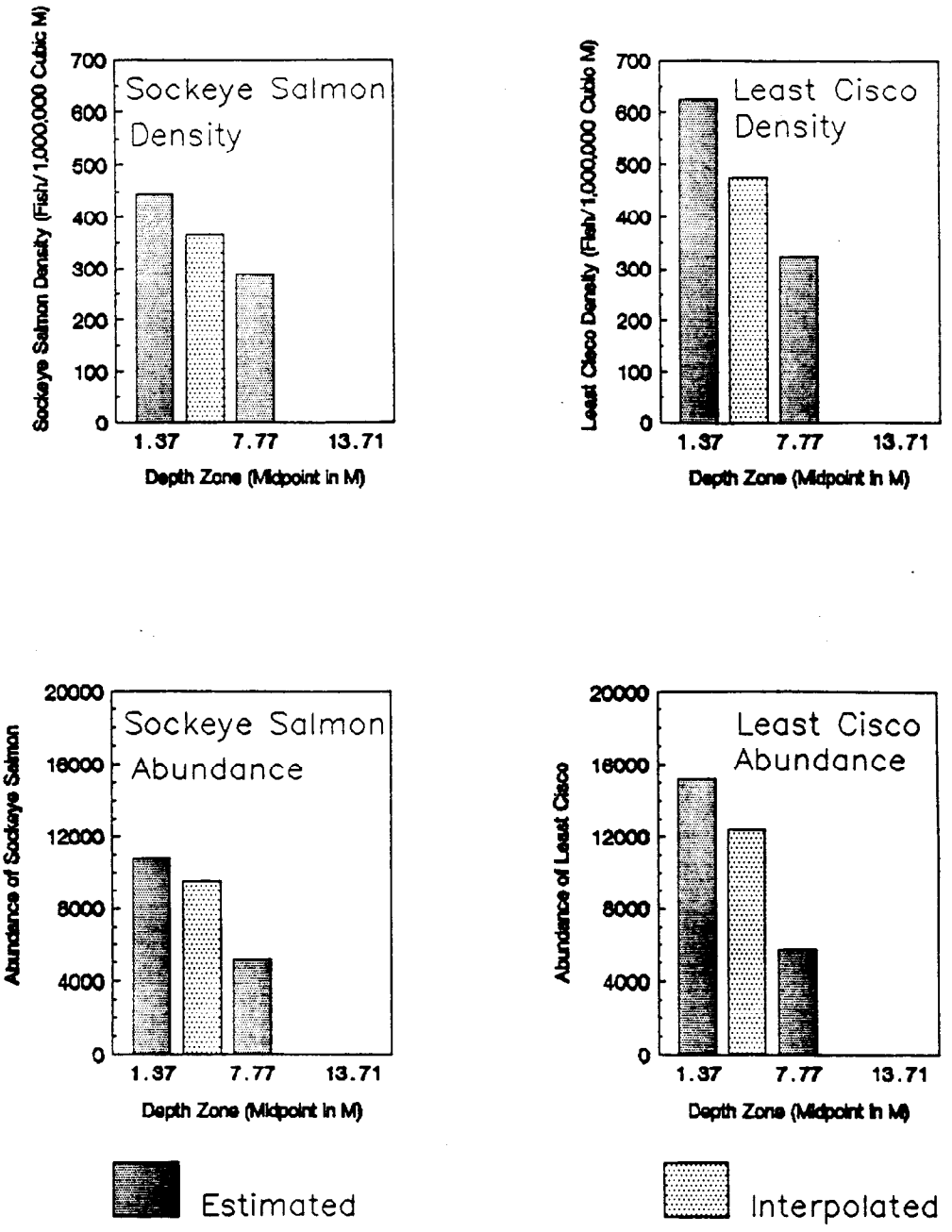

Figure 3. Estimated density and abundance of sockeye salmon and least cisco in Harding Lake, 1988.

Table 4. Length and weight statistics for sockeye salmon, least cisco, and Arctic char caught while tow netting Harding Lake in 1988.

Statistic	Sockeye Salmon	Least Cisco	Arctic Char
Length Statistics by Age Group:			
Age 0:			
Sample Size:	147	2	2
Mean:	72 mm	111 mm	173 mm
Minimum:	62 mm	106 mm	163 mm
Maximum:	83 mm	117 mm	183 mm
Variance:	17 mm	30 mm	200 mm
Standard Error of Mean:	0.34 mm	3.89 mm	10.00 mm
Age 1:			
Sample Size:	0	14	0
Mean:		146 mm	
Minimum:		123 mm	
Maximum:		163 mm	
Variance:		182 mm	
Standard Error of Mean:		3.60 mm	
Age 2:			
Sample Size:	0	39	0
Mean:		161 mm	
Minimum:		137 mm	
Maximum:		178 mm	
Variance:		59 mm	
Standard Error of Mean:		1.23 mm	
Age 3:			
Sample Size:	0	1	0
Mean:		192 mm	
Minimum:		192 mm	
Maximum:		192 mm	
Variance:		0	
Standard Error of Mean:		0	
All Age Groups Length Statistics:			
Sample Size:	147	219	2
Mean:	72 mm	155 mm	173 mm
Minimum:	62 mm	106 mm	163 mm
Maximum:	83 mm	193 mm	183 mm
Variance:	17 mm	187 mm	200 mm
Standard Error of Mean:	0.34 mm	0.92 mm	10.00 mm
All Age Groups Weight Statistics:			
Sample Size:	17	121	2
Total Weight:	59 gr	3,818 gr	112 gr
Average weight:	3.47 gr	31.55 gr	56.00 gr

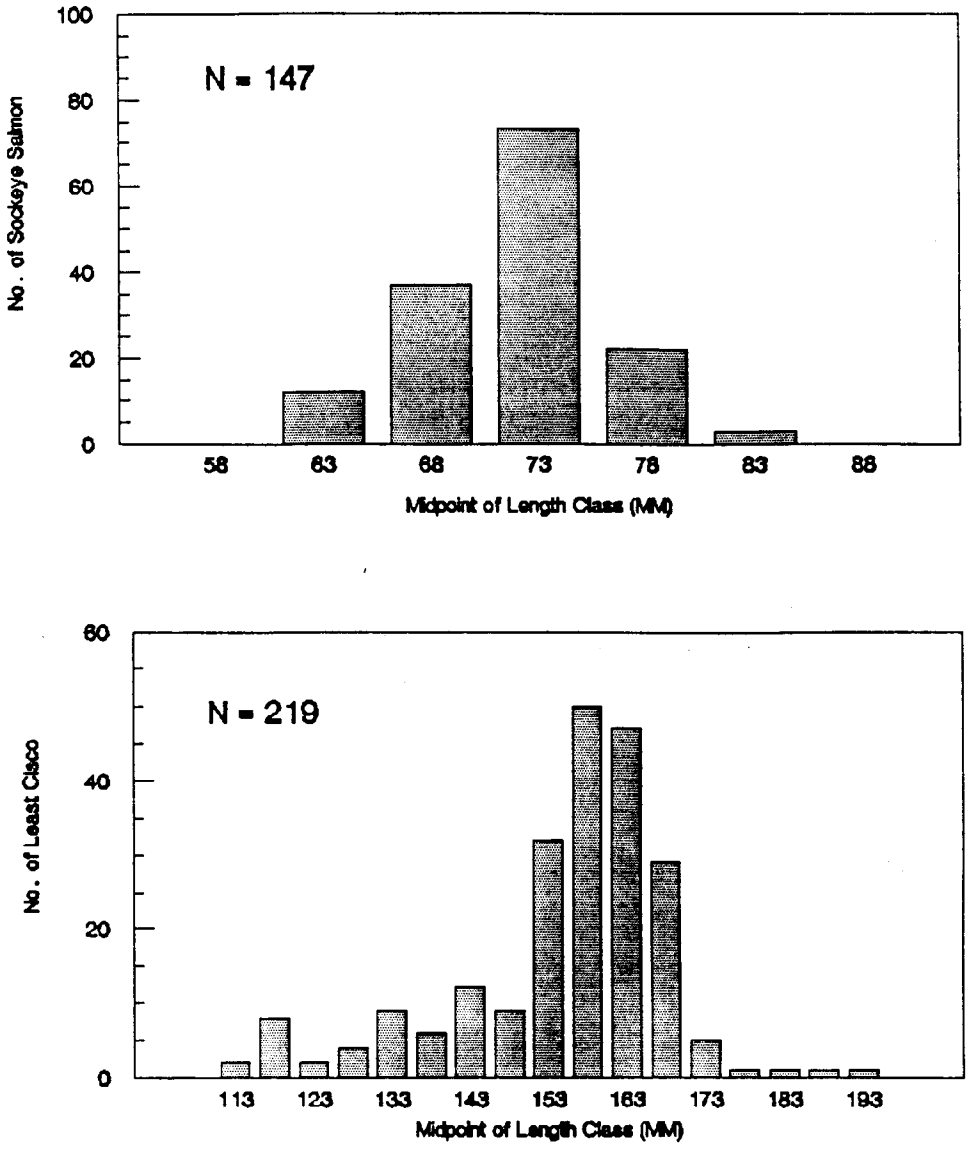

Figure 4. Length frequency of sockeye salmon and least cisco caught in tow nets in Harding Lake, 1988.

Table 5. Reported average lengths of age zero sockeye salmon caught in tow nets fished in various Alaskan lakes.

Source	Location	Year	Length of Age 0 Sockeye Salmon (mm)
Parker & Barton (1974)	Becharof Lake	1974	Ave. = 69.6 mm from 9/25 to 10/2
Parker & Barton (1974)	Upper Ugashik Lake	1974	Ave. = 60.5 mm from 9/25 to 10/2
Parker & Barton (1974)	Lower Ugashik Lake	1974	Ave. = 55.5 mm from 9/14 to 9/16
Rogers & Newcome (1975)	Amanka Lake	1974	Ave. = 48.4 to 56.3 mm in various areas of the lake on 8/30/74
Rogers & Newcome (1975)	Ualik Lake	1974	Ave. = 35.0 to 57.3 mm in various areas of the lake on 8/27/74
Waltemyer (1981)	Kenai Lake	1974-1979	Ave. = 40.0 to 61.3 mm from 8/27 to 9/26
Waltemyer (1981)	Skilak Lake	1974-1979	Ave. = 43.0 to 59.0 mm from 8/31 to 9/24
Waltemyer (1981)	Tustemena Lake	1974-1979	Ave. = 55.3 to 62.9 mm from 9/4 to 9/24

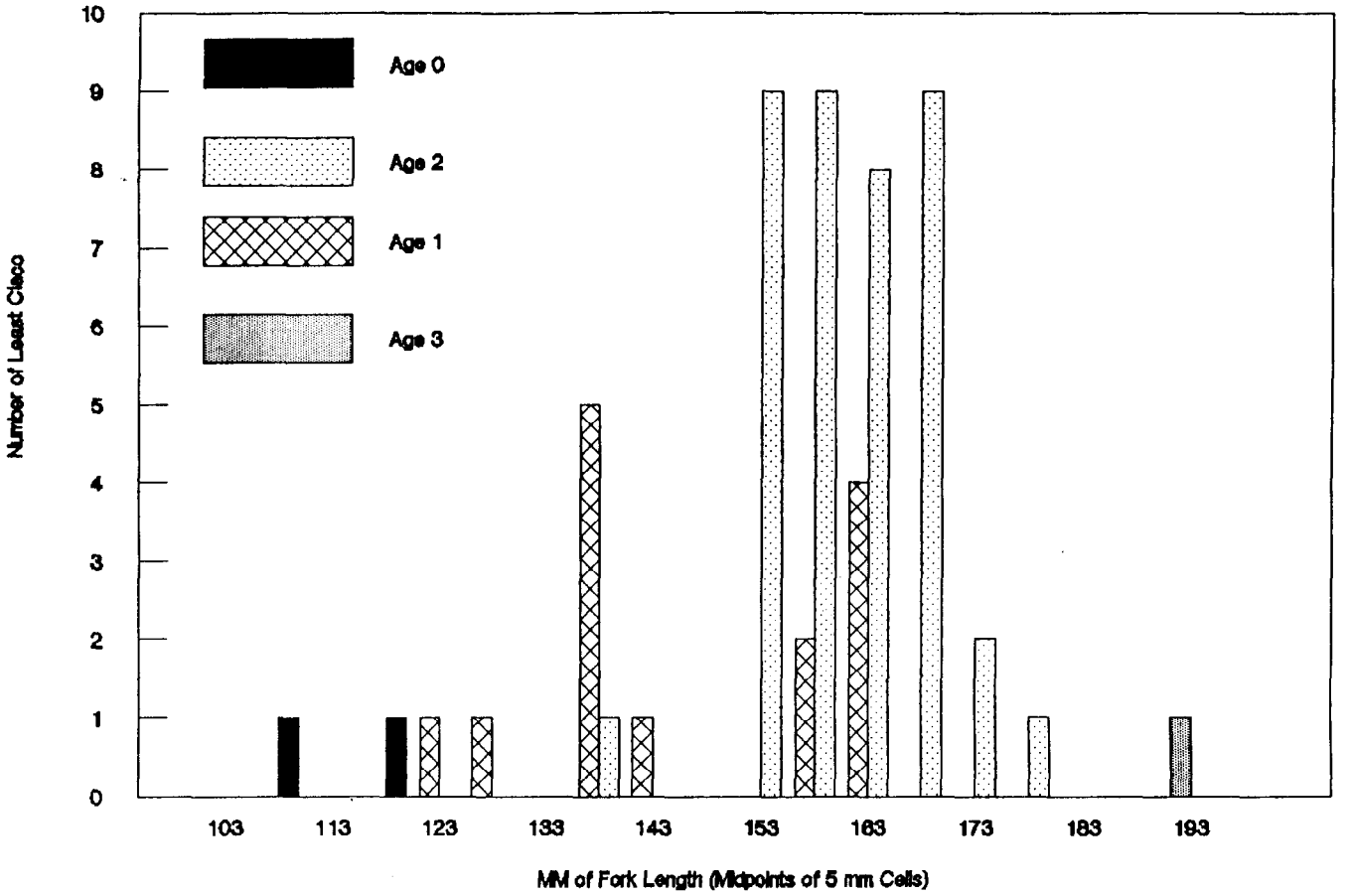

Figure 5. Length frequency of age 0, 1, 2, and 3 least cisco caught with tow nets in Harding Lake, 1988.

361 mm FL are found (Hallberg and Holmes 1987). About one half of the least cisco sampled from Harding Lake had mature ovaries and testes indicating that age at maturity for the population is at least somewhat similar to the Chatanika River least cisco population. However, average length of Harding Lake least cisco at age 2 was only about 56% of that reported for the Chatanika River indicating that least cisco from Harding Lake grew at a substantially lesser rate than do least cisco spawning in the Chatanika River.

During early October in Harding Lake, sockeye salmon were primarily consuming cyclopoid copepods (50%) followed by harpacticoid copepods (30%) and cladocerans (20%) (Figure 6). Least cisco fed on those same food types (cyclopoid copepods: 40%; harpacticoid copepods: 25%: cladocerans: 10%) along with a small proportion of terrestrial insects (10%), chironomids (10%), and oligocheata (5%) (Figure 6).

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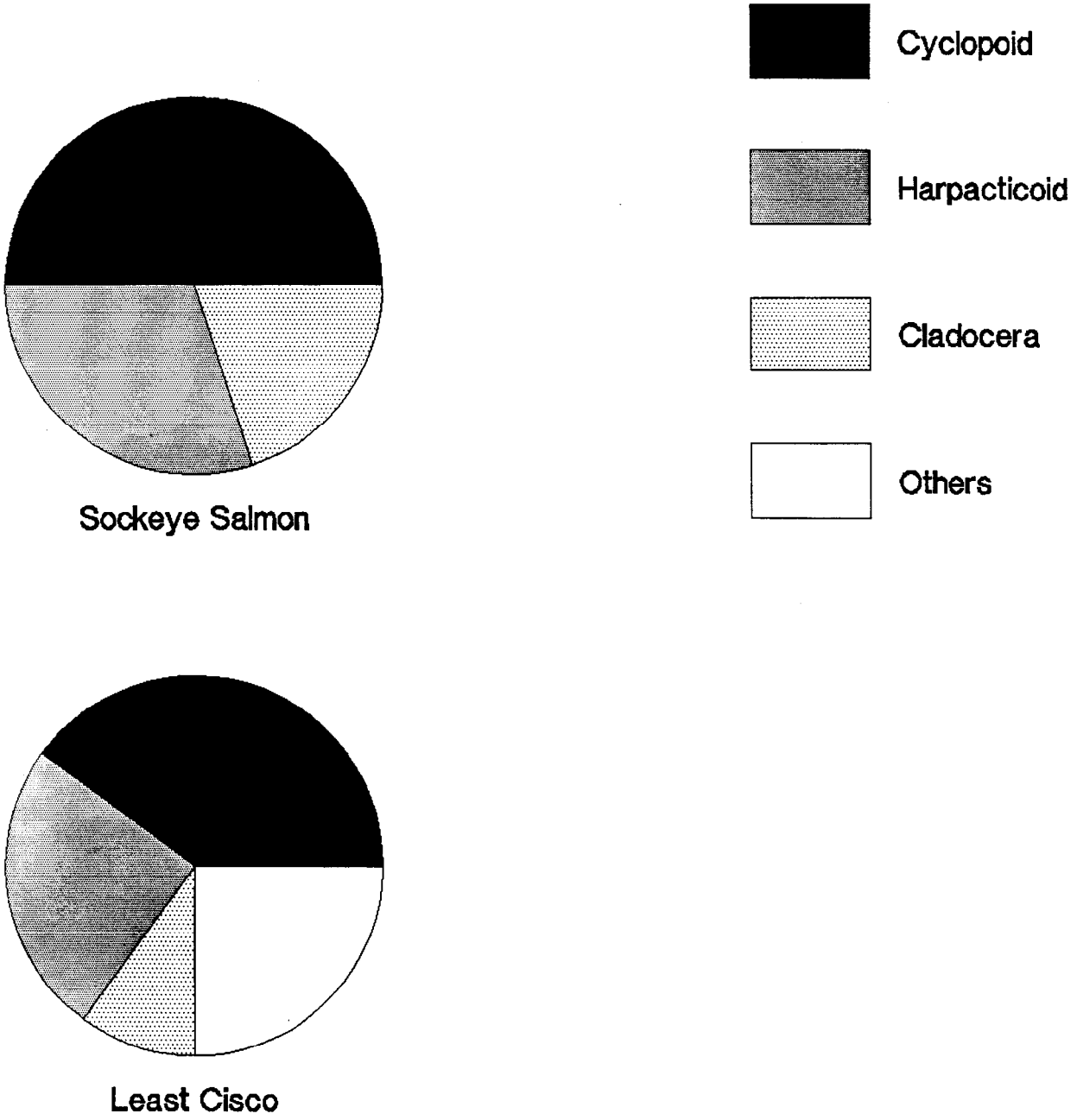

Figure 6. Food types (percent) found in stomachs of sockeye salmon (n = 30) and least cisco (n = 15) caught with tow nets in Harding Lake, 1988.

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